

from the water and from land. Nine types of shoreline in the Galveston Bay system were surveyed for the presence of permitted and unpermitted discharges. These shoreline types represent a cross section of the types found throughout the bay system and are fairly inclusive of what may be found in any estuarine system. A total of 159 linear miles of shoreline/stream were designated for survey. The nine shoreline segments surveyed in this study are:

Cedar Bayou: Segment 0901, 19 river miles, industrialized/urban tributary.

Galveston Bay: Segment 2421, 22 shoreline miles, developed shoreline.

Double Bayou: Unclassified Segment in Chambers county, 22 river miles, agricultural/rural tributary with oil field activity.

East Bay: Segment 2423, 40 shoreline miles, marinas and agricultural/undeveloped open bay shoreline.

Chocolate Bayou: Tidal segment 1107, 14 river miles, moderately developed rural tributary.

Armand Bayou: Tidal segment 1113, 8 river miles, suburban tributary.

Dickinson Bayou: Tidal segment 1103, 15 river miles, moderately developed suburban/rural tributary.

Dickinson Bayou: Above tidal segment 1104, 7 river miles, rural non-tidal tributary.

Carancahua Lake and Bayou: Unclassified, 12 shoreline and river miles, rural secondary bay with oil field activity.

3.0 METHODOLOGY

3.1 Approach and Overview

By their very nature the locations of, or other data relative to, unpermitted discharges into coastal waters are not likely to be discernable from the records of regulatory governmental agencies. Identifying these unpermitted discharges in the Galveston Bay system is exacerbated by the number of permitted discharges whose physical locations are uncertain or unknown to the regulatory agencies, the large number of legally permitted discharges, and the wide variety and great length of shoreline types with limited accessibility. The limitations of the "water's edge perspective" and the lack of a definitive indicator of a discharge point other than the visual identification of a pipe, outfall, or discharge point with effluent also confound efforts to comprehensively survey an area in a single,

reasonably short period of time. Thus, a survey undertaken by simply cruising along the shoreline by boat in search of discharge structures is an ineffective and inefficient means to meeting project objectives.

Our approach to designing the study plan was influenced by the following considerations. The expanse of geographic area in this study, and in subsequent applications of the techniques developed herein, is too large and diverse to simply cruise the shoreline and look. A step-wise approach to each area (river or shoreline segment) was needed so that proper resources could be directed where they would do the most good (that is, be most effective and efficient). Similarly, significant portions of the survey effort could be wasted in erroneous documentation of the presence of a permitted discharge or in tedious and unproductive searches of undefiled shoreline

The approach we adopted was to categorize each segment of river/shoreline with regard to the type and magnitude of discharges likely or known to be present in the area. These data were plotted on topographic maps and were augmented with data from visual observations made during low altitude overflights of each segment. The aerial surveys were conducted to (1) confirm known or permitted discharge points, (2) to look for visual evidence of others, (3) to designate areas within each segment as being of high interest, suspicion, or probability, (4) to eliminate some areas from further consideration, (5) to get an overview of how to approach the entire segment from the logistical perspective, and (6) to annotate the maps and data bases accordingly. From this data base, we developed a logistics plan to perform a shoreline survey by appropriate boat for each shoreline/river segment, selecting the best means, equipment, survey plan, and access for the specific segment.

A limitation to this method, as well as to all methods considered, is in the detection of underwater discharges. We are aware of which could be applied to the diversity of shoreline types on the scale of miles undertaken here. We acknowledged this shortcoming in our proposal and emphasize here that underwater discharges were not addressed, except where their structure was visible above the water line. There is no evidence either before or following our surveys to suggest that submerged (and hence concealed) unpermitted discharges constitute a significant contaminant input to the bay system.

3.1.1 Clearance and Priority Ranking Criteria

A set of criteria was developed for evaluating and ranking sections of the shoreline segments based on the presence of certain features observed from the air. The purpose of the clearance and ranking is two-fold. The presence of features or structures along or near the shoreline which might be associated with discharge activities would count toward high grading an area. Unless there were evidences to suggest a connection to the shoreline (buried pipeline scars, a pipe on

the surface, or a discharge ditch or canal) we limited the inshore boundary of the search area to approximately 500 meters from the shoreline. Such areas received close scrutiny during the boat survey. The absence of any such features (which would be required as a point of origin for the discharge) resulted in a section of the shoreline segment being low graded. Such a low graded area was eliminated from further boat survey if the survey effort required in that area was a difficult one, or received a fast cursory survey, if it could be done enroute to another section.

From the aerial survey and historical data base, each portion of a shoreline segment was categorized with respect to the need for subsequent boat survey. A particular shoreline portion was surveyed from the water (boat survey) if it was accessible by boat and one of the following qualifying criteria were met:

- 1) the visible presence of a known or suspected discharge structure (pipe, outfall, ditch, etc.)
- 2) the presence near the shoreline of a building structure or facility which is often associated with discharges (manufacturing plant, refinery, petroleum gathering, power generation)
- 3) the presence of man-made structures in close proximity to the shoreline in such concentration which makes resolution of possible discharges or sources impossible from the air

A portion of the shoreline was eliminated from boat survey if none of the above qualifying criteria characterized the particular shoreline portion.

In those instances where one of the qualifying criteria were met but the shoreline appeared inaccessible by boat, other means (on foot, via land, etc.) were used to investigate the features of interest.

Thus, all portions of the shoreline segments were classified into one of three categories:

- 1- requiring boat survey,
- 2- not requiring further boat survey,
- 3- requiring a confirmational up-close survey of the observed suspect features, but by a means other than by boat.

With this background information and plan, we dispatched field crews with survey objectives specific to each target segment. The boat surveys provided on-site confirmation of discharge points (both permitted and unpermitted, and actual, potential, or suspected).

Narrative and photographic documentation was obtained during the boat surveys, and location information (latitude and longitude of the discharge point) was provided by LORAN C. It was intended that GPS (Global Positioning System) be used in lieu of LORAN C for those times in which it was available. GPS is a satellite based radio navigation system which will include 18 satellites in 6 orbits providing positional accuracy on the order of meters when complete. However, subsequent to the development of the work plan the government reduced the accuracy of the GPS as part of their testing program. The resultant loss of accuracy combined with the intermittent availability of the GPS made the proposed use of GPS for positioning an impracticality for this pilot study. However, when the accuracy is reestablished it should be used as the positioning system of choice for this type of study.

3.2 Information Acquisition - Data Available

3.2.1 Maps and Charts

Commonly available nautical navigation charts and county road maps did not provide adequate detail or scale resolution to be of value in the study. Seven and a half minute quad sheets were obtained from the Texas Natural Resources Information System in Austin to encompass the entire study areas. These maps were used to develop the study design and were used in the field for data annotations as well as served as the base maps for the final reporting of data.

3.2.2 Permitted Discharge Data

We obtained a listing from the Texas Water Commission of the permitted discharges on each of the stream segments. Although these data do not include precise locations of the actual discharge points, this data base was the beginning basis for identification of permitted discharges. Visits were made to both the headquarters offices in Austin and the regional office in Deer Park to ensure we had an exhaustive listing of permittees for the segments to be surveyed.

Although stormwater discharge currently requires no permit (and hence there is no central regulatory agency), stormwater discharge points were identified and catalogued separately inasmuch as tentative identification would permit. Unlike permits from the TWC, we were unable to identify any municipal, city, or governmental agencies or offices which could speak to the issue of stormwater drainage in a thorough and comprehensive manner in regard to where the collection and discharge points into the stream segments are. Thus, we approached the stormwater discharge issue without any background information as to locations.

The Texas Railroad Commission (RRC) regulates and permits the discharge of produced waters from oil and gas production activities.

Similar to our contact with TWC, a listing of permitted produced water discharge permits was obtained either from their computer generated listings or from personal visits to their files.

Pipeline routes crossing navigable waters (and even most shallow bayous) were marked with appropriate identifying signs and warnings regarding anchoring and dredging. Even from the air, pipeline routes posed little problem in identification and recognition. Since these are not discharges, their locations were not logged in the data base nor were they documented in the field.

3.2.3 Permitted Discharges Data Base

The permit data was compiled using Reflex Plus software on an Apple Macintosh personal computer. The data base was designed to allow updating positional and descriptive information on the permitted discharges, and to also incorporate information on non-permitted discharges obtained from the field surveys. Data field entries included Permittee Name, Permit Number, Stream Segment Number, and a Description of the Location and Type of waste or process. As each permit was entered into the data base it was assigned a sequential GBNEP Number, a unique numerical identifier which was used on the maps and in cross referencing sightings in the field.

3.2.4 Mapping

Permitted and known discharge points obtained from the Railroad Commission and Texas Water Commission files were plotted on the topo maps in approximate position from the location descriptions given for verification in the field surveys, and as partial fulfillment of reporting requirements for the final report. The GBNEP Number was annotated on the map with an arrow pointing to the approximate location of the facility or discharge.

These draft maps with the annotated GBNEP numbers and the permitted discharge listings compiled by segment were used in both the aerial and boat surveys as the basis on which locations were confirmed and new sightings were recorded.

3.3 Observational Data and Documentation

3.3.1 Aerial Surveys

Aerial surveys were conducted over each stream or shoreline segment following compilation and plotting of the permitted discharges data. Multiple low altitude (500 to 1000 feet above ground level) circling passes were made in a Cessna 172 aircraft cruising in slow flight at about 70 knots. A two place Cessna 152 was proposed for the survey aircraft, but it was found to be too confining in the cockpit to attend to all the paperwork, photography, navigation, and flying requirements.

In all but one instance, the aerial survey crew consisted of the pilot (the project's principal investigator) and one observer. During the last survey the principal investigator was accompanied by two observers. Having a second observer, familiar with the project, on board made a significant improvement in the aerial survey from the standpoint of workload.

Equipment necessary for the aerial survey included an aircraft with VHF radio, Mode C transponder, noise cancelling voice activated headsets and intercom for pilot and crew, a pocket dictation tape recorder and an auto focus/auto wind 35 mm camera with date/time annotation. We obtained excellent results with a Nikon Zoom-Touch 500, which has a 30 to 80 mm zoom and allows one hand operation for all functions. The proximity of some of the survey segments to airport traffic areas, and the Houston Terminal Control Area demand radio communication with the appropriate air traffic controllers, and the altitude reporting transponder is required by the FAR's (Federal Aviation Regulations). In fact, the busyness of the airspace in the vicinity of Ellington Field, Houston Gulf, and LaPorte airports was such that an observational crew of two should be required, as the pilot has his hands full just flying the plane. The intercom and headset allow meaningful communication even with the windows open and help alleviate fatigue in both the pilot and observer. These equipment requirements are noted as a precaution against attempting to accomplish subsequent surveys with inadequate aircraft or insufficient crew. Attempting to accomplish an equivalent survey with an ultralite aircraft or even with a no-radio/no-transponder aircraft would not be safe or prudent (and in some places it would be illegal).

Aerial observation log sheets (Figure 3-1) were compiled from the data base so that all observations from the aerial survey would be identifiable through an A/O (aerial observation) number. Each aerial observation file entry included a field for the segment number, the date, the time which was annotated on each picture taken, a description of the observation and its location, and a likely GBNEP cross reference number (i.e., A/O 47 is probably GBNEP # 119) or a new GBNEP number for unpermitted sites. The location of each observation was plotted on the maps using landmarks to estimate the location, and these locations were checked against aerial photos when processed the next day. Topo maps were marked directly in the air, not only with A/O numbers but with notes relating to logistical considerations. These latter would include such things as boat launching points, impasses to boat navigation on the water, areas of shoreline to be skipped in the boat survey, and particular areas or features to investigate in great detail.

As each permitted facility or suspected discharge was overflowed, oblique photographs were taken from the open window of the aircraft as it circled the observed feature. Data was recorded for each A/O on the log sheets and similarly annotated on the map. VHS video

Figure 3-1

Galveston Bay National Estuary Program

Aerial Observations Log

<u>A/O no.</u>	<u>segment</u>	<u>date</u>	<u>time 1</u>	<u>time 2</u>	<u>no of photos</u>
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186

location:

description:

<u>A/O no.</u>	<u>segment</u>	<u>date</u>	<u>time 1</u>	<u>time 2</u>	<u>no of photos</u>
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187

location:

description:

<u>A/O no.</u>	<u>segment</u>	<u>date</u>	<u>time 1</u>	<u>time 2</u>	<u>no of photos</u>
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188

location:

description:

<u>A/O no.</u>	<u>segment</u>	<u>date</u>	<u>time 1</u>	<u>time 2</u>	<u>no of photos</u>
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189

location:

description:

<u>A/O no.</u>	<u>segment</u>	<u>date</u>	<u>time 1</u>	<u>time 2</u>	<u>no of photos</u>
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190

location:

description:

recording was made during much of the aerial survey, not as part of the documentation, but rather to facilitate locating some of the features by the boat crew during their subsequent survey. Upon completion of the aerial survey, the film was developed with two prints made from each frame, and the negatives remaining uncut. At the beginning of each roll was an identification picture naming the segment and date of survey. Thus, with this roll identification and each picture annotated with the hour and minute, each A/O photographed could be positively identified. One copy of each picture was placed in a manual with the appropriate A/O designator and GBNEP number written on the overlay. The other picture was archived for use in the final report. Suspected unpermitted discharges detected during the aerial survey were identifiable from the field logs through the A/O number and identifiable in the data base through their unique GBNEP number. Such discharges were high-graded for subsequent confirmation and documentation during the boat surveys.

While performing the aerial survey, it was possible in most cases to positively identify permitted discharges from the descriptions in the permits. Exceptions to this were when the permittee was a very small facility that couldn't be found from the description given, and when there were multiple permitted facilities on adjoining property (such as on Cedar Bayou). If the aircraft were to be equipped with LORAN C, it would be possible through the aerial surveys alone, to document most of the permitted discharges with photographs and positional information sufficient for this type survey.

3.3.2 Boat Surveys

It was our intent as proposed to complete all aerial surveys prior to the boat surveys. Completion of the first aerial survey on two segments changed our thinking on this concept. The amount of data and the variability and uniqueness of the environments to be surveyed was more than anticipated. To retain a "feel" for the segment developed during the aerial survey, we felt it imperative to process the photographs and data as quickly as possible and perform the boat survey soon after the aerial survey, and before proceeding with another aerial survey. There were exceptions to this. For example, our aerial survey of the western shore of Galveston Bay discerned only the permitted discharges and that the entire shoreline would need to be scrutinized by boat due to the density of residential dwellings. Therefore, we proceeded with other segments before returning to this difficult and tedious segment.

Two boats were used for this aspect of the survey. The boats were trailered to each segment. The primary vessel was a 17' Boston Whaler with a 90 hp outboard engine, capable of cruising at approximately 50 mph enroute to and from survey areas. The boat was equipped with power tilt trim (which permitted operation in shallow waters, less than 2'), a Northstar 800 Loran receiver, Hummingbird depth finder, compass, VHF marine radio, and 24 gallons of fuel. The secondary boat was a 12' flat bottom aluminum John boat with a 9 hp outboard and an electric trolling motor. This boat was required in most of Armand Bayou, where gasoline outboard motors are prohibited. The Northstar Loran and a handheld VHF radio were installed for this one survey. The boat survey crew was comprised of two individuals, one having been on the aerial survey.

A shore observation log was generated from the data base program (Figure 3-2). The log had fields for the date, segment number and area, latitude, longitude, Loran C time delays, number of photos taken, time interval on photographs, description and comments. The key entry on the shore observation log was the Shore observation number (S/O #). Each observation of a permitted, unpermitted, or suspected discharge was identified with an S/O #.

Figure 3-2

GALVESTON BAY NATIONAL ESTUARY PROGRAM
SHORE OBSERVATION LOG

DATE: _____ SEGMENT: _____ AREA: _____

SHORE OBS # 289 A/O #: _____ PHOTO TIME: _____

LAT: _____ TD: _____ # OF PHOTOS: _____

LONG: _____ TD: _____

DESCRIPTION/COMMENTS:

SHORE OBS # 290 A/O #: _____ PHOTO TIME: _____

LAT: _____ TD: _____ # OF PHOTOS: _____

LONG: _____ TD: _____

DESCRIPTION/COMMENTS:

SHORE OBS # 291 A/O #: _____ PHOTO TIME: _____

LAT: _____ TD: _____ # OF PHOTOS: _____

LONG: _____ TD: _____

DESCRIPTION/COMMENTS:

Both the maps (annotated with the permitted information and the aerial observations) and the photographs from the aerial surveys accompanied the boat crew. Thus, it was possible to correlate sites through their GBNEP number and the aerial observations (through their A/O #) with the S/O number in the field. Photographs were taken of all actual or suspected discharges. Thus, photographs depicting the aerial view and the view from the water surface were obtained. Exceptions to this were permitted sites which were never located or any type site which was not accessible by boat or from land. For the latter, the aerial photographs provide the only documentation.

As with the aerial photographs, duplicate prints were made, and the uncut negatives provided a title and date print for identification. One set of the photographs was correlated with the aerial photographs, providing aerial and surface documentation for most of the discharges. Discharges discovered during the boat surveys have photodocumentation from the surface perspective only.

3.4 Survey Variability

As a measure of the efficiency of these survey methods in detecting unpermitted discharges, five randomly selected one mile transects within three surveyed segments were the object of a repeat boat survey. The efficiency or effectiveness we were testing was of two types. First, would simple boat surveys along an entire shoreline yield results equal to or greater than those from the combined aerial/boat surveys as implemented? Secondly, the statement of work required an investigation into variability of results between surveyors. Thus different personnel had to be employed on the resurvey efforts. Segments and portions of segments which were inaccessible by boat (and Armand Bayou because of the logistical problems of needing two different boats) were eliminated from the selection process. Repeat boat surveys were performed on portions of East Bay, Galveston Bay, and Dickinson Bayou. The boat crew in this instance was not same as the crews that conducted the initial boat surveys.

These surveys were performed "blind". That is, the crew was not provided any information or pictures as to what may be expected in the areas. New topo maps, lacking any annotation, were the only data provided. The boat cruised as close to the shoreline as depth would permit, as both observers scanned for evidences of discharges of any kind. Binoculars were employed for all of East Bay and Galveston Bay because shallow water in the former and pier extensions in the latter kept the boat 50 to 200 meters from shore, except when a particular feature was to be investigated and photographed. At these times, boat progress was extremely slow with the motor in the tilt up position. It would be quite impractical to conduct the entire surveys at the speed and in this configuration required for these closer looks.

Those portions of segments re-surveyed were:

East Bay beginning at Shirley's Blue Beacon Bait Camp on Bolivar Island, 29°25.75', 94°42.56', and proceeding east along the south shore of East Bay to longitude 94°38.36'. From that point we proceeded across the bay to 29°32.58', 94°38.54' to resume the survey westerly along the north shore to 29°31.55', 94°43.59'.

Galveston Bay beginning at the marina at 29°28.00', 94°55.33' and proceeding north along the shore to latitude 29°29.76'. From that point we proceeded north of Eagle Point Marina to begin re-survey toward the north at 29°30.58' on the western shore of Galveston Bay. This section was terminated at 29°30.89', 94°59.45'.

Dickinson Bayou beginning at the highway 146 bridge (29°27'49', 94°58.23') and proceeding upstream to 29°27.62', 95°00.68'

As evidence of actual or potential discharges was discovered, positions and descriptions were noted, photographs were taken, and positions annotated on the new maps. These data were compared with results from the aerial/boat survey investigations to determine the efficacy of the method employed. The efficiency of our method of survey is best illustrated by comparison of our blind confirmation survey result with those of the original survey for East Bay. During the confirmation survey we found the same and only discharge on the north shore that we had observed from the air. This was a permitted site but had its origin approximately 1 mile away and inland from the point of discharge on the shore. Had we only observed this from the shoreline, it is very unlikely that we could have made the connection between this discharge site and the permit. However, the pipe lying on the ground (and overgrown by brush along parts of its length) was visible from the air and trackable to its source. Another measure of the efficiency is the time required to survey these distances on this type of shoreline. The blind boat survey took about 4 hours from the time the boat was launched until our return to the marina. The same distance could be covered by air in less than 20 minutes over the shorelines investigated, and a total time of 30 minutes from the nearest airport. During this survey, we discovered the presence of an unpermitted discharge from under the building at the marina (Shirley's Blue Beacon Bait Camp). The 4" PVC pipe (no flow at the time of observation) was discovered by chance when we left the marina. While the original survey was limited to the bay portion of Segment 2423 and did not include the intracoastal waterway, the area in which the bait camp was located was not part of the areal extent of the survey design, but we noted the pipe's presence and its absence from the first survey report. It was well hidden beneath the marina structure, and would be very

easily missed on a routine survey of the area, and it certainly would not be indicated from the air.

The resurvey of the Galveston Bay shoreline showed the greatest disparity between the original and confirmation surveys. From the air, the large permitted sites were visible and noted. From the shoreline they were not, and were easily overlooked. The number of street and storm drains appeared to be potentially quite large and not plotable from the air. There were too many, their presence was obscured by the density of housing, trees, brush, etc. Thus, on this type of shoreline a shoreline survey by boat of essentially the entire length, preceded by an aerial survey to note the major permittees which are usually some distance from the shoreline and easily missed by boat, is the only feasible approach. In our re-survey utilizing two observers (one with binoculars) in addition to the boat driver, we reported significantly more potential discharges. However, these were all likely storm drains which were mere culverts under the road which paralleled the shoreline or bulkhead and lawn drains from residential properties. This difference is attributable to the lack of a good definition or criteria as to what constitutes an unpermitted discharge. None of the observed structures were discharging effluents at the time of observation, and some of the "discharge" structures we reported were as small as 1" pipes.

The re-survey of the Dickinson Bayou segment illustrates the greatest need for the combined aerial/boat survey approach. During both the original and confirmation boat surveys we did not observe five of the permitted or aerial observation sites which were either off the shoreline a short distance, or inaccessible by boat due to the extensive mud flats and shallows. These were only discernible from the air. In the original survey a discharge was observed at the marina at highway 146. In the resurvey no discharge or pipes were seen at this same area. Our inability to detect it was probably due to its being concealed by the congestion of boats (stacked two and three deep) at the docks. In contrast one permitted pipe was missed in the original boat survey and detected in the re-survey. Also two storm drains and two other unidentified pipes were noted coming from shoreline residences in the resurvey. Their omission in the original survey could be accounted for either by tide stage or concealment by boats at the docks during the initial survey.

Overall the confirmation surveys indicate that the aerial/boat survey method will provide the most efficient and complete coverage. However, there are likely to be omissions even with this double coverage, especially in areas of high residential and waterfront/marina type development.